U.S. Fish & Wildlife Service

Chinook Salmon Spawning Ground Surveys on the Entiat River, 2014

Gregory S. Fraser and Charles O. Hamstreet

U. S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
Leavenworth, WA 98826

***On the cover**: A Chinook Salmon redd in the Entiat River.*

The correct citation for this report is:

Fraser, G. S. and C. O. Hamstreet. 2015. Chinook Salmon spawning ground surveys on the Entiat River, 2014. U. S. Fish and Wildlife Service, Leavenworth, Washington.

CHINOOK SALMON SPAWNING GROUND SURVEYS ON THE ENTIAT RIVER, 2014.

Study funded by

U.S. Bureau of Reclamation
And
U.S. Fish and Wildlife Service
Fisheries Operating Needs System
FONS # 2009-078

Authored by

Gregory S. Fraser
Charles O. Hamstreet

U.S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
7501 Icicle Rd.
Leavenworth WA 98826

Final

May 2015

Disclaimers

Any findings and conclusions presented in this report are those of the authors and may not necessarily represent the views of the U.S. Fish and Wildlife Service.

The mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

CHINOOK SALMON SPAWNING GROUND SURVEYS ON THE ENTIAT RIVER, 2014.

Gregory S. Fraser
Charles O. Hamstreet

U.S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
7501 Icicle Rd.
Leavenworth, WA 98826

Abstract–This report summarizes the results of spring and summer Chinook Salmon (*Oncorhynchus tshawytscha*) spawning ground surveys conducted in the Entiat River basin in 2014. Data were collected on redd location, timing of redd construction and redd superimposition rates by summer Chinook Salmon on spring Chinook Salmon. Salmon carcasses were recovered, identified to species and analyzed for run, gender, age, rearing origin, and any research tags or marks they may have contained. The data were used to describe the population of returning adults from each run, using metrics including spawn escapement, natural- and hatchery-origin proportions, age class composition, and hatchery specific contribution to the spawning population. Opportunistic data were also collected on Sockeye Salmon (*O. nerka*) and Coho Salmon (*O. kisutch*) spawning in the Entiat River basin.

In 2014, a total of 102 spring Chinook Salmon redds and 233 summer Chinook Salmon redds were identified. The spawning run escapements were 245 spring Chinook Salmon and 559 summer Chinook Salmon. Superimposition rates of summer Chinook Salmon redds on spring Chinook Salmon redds were 27% in total and were lower in upstream reaches than downstream reaches.

In 2014, carcass recoveries consisted of 26 spring Chinook Salmon and 89 summer Chinook Salmon, with carcass recovery rates for each run of 0.11 and 0.16, respectively. Natural-origin fish accounted for 92% of the spring Chinook Salmon spawning run escapement, and 75% of the summer Chinook Salmon spawning run escapement. The origin of the two hatchery spring Chinook Salmon carcasses recovered could not be determined. The majority of hatchery summer Chinook Salmon carcasses recovered on the spawning grounds originated from Entiat National Fish Hatchery (75%), and out-of-basin facilities including; Dryden Acclimation Pond (10%), Turtle Rock Hatchery (10%), and Chelan Falls Hatchery (5%). The age class composition of spring Chinook Salmon was made up of 8% age-3, 83% age-4 and 8% age-5 fish. For summer Chinook Salmon, the age class composition was 6% age-2, 19% age-3, 55% age-4, 19% age-5 and 1% age-6.

Page intentionally left blank

Table of Contents

List of Figures

List of Tables

Introduction

The Entiat River has been surveyed for Chinook Salmon (*Oncorhynchus tshawytscha)* spawning since 1962 for the spring run and since 1957 for the summer run. Chinook Salmon spawning ground surveys consist of both redd counts and carcass recovery, and are intended to be a complete census of the primary spawning areas in the Entiat River basin. In the past two decades, these surveys have become more rigorous in regards to effort and areas surveyed. This report details the methods and results of spawning ground surveys for Chinook Salmon in the Entiat River for the 2014 return year. The United States Fish and Wildlife Service (USFWS) Mid-Columbia River Fisheries Resource Office (MCRFRO) has been conducting these surveys since 1994.

The objectives of the spawning ground surveys are to:

- Assess the quantity and distribution of redds to estimate the spawning population of spring and summer Chinook Salmon within portions of the Entiat and Mad rivers.
- Evaluate the contribution of hatchery spring and summer Chinook Salmon to the spawning population, which includes documenting redd superimposition by summer Chinook Salmon on ESA-listed spring Chinook Salmon.
- Document the spawning occurrence of Sockeye Salmon (*O. nerka)* and Coho Salmon (*O. kisutch)* during Chinook Salmon surveys.

Study Area

The Entiat River basin is located in Chelan County, in north-central Washington State (Figure 1). The river originates in a glaciated basin of the Cascade Mountains and flows approximately 69 river kilometers (rkm) to join the Columbia River at rkm 778 (Mullan et al. 1992). Peak discharge occurs during spring run-off, the highest flow recorded (1957–2015) was 6,430 cfs on June 10, 1972 (USGS gauge # 12452800, Entiat River near Ardenvoir, WA). The low-flow period occurs from August through March with mean flows of 134 cfs (1975–2015). Sporadic weather events during this period may temporarily increase flows (USGS gauge # 12452800, Entiat River near Ardenvoir, WA). The two major tributaries of the Entiat River are the Mad River and the North Fork which enter the Entiat River at rkm 16.3 and 54.7, respectively. The present upstream limit of anadromy is Entiat Falls (rkm 54.4). River kilometers are measured from the confluence of the Entiat River with the Columbia River (rkm 0).

The Entiat River system drains an area of approximately 671 square kilometers. The watershed is nearly 68 kilometers in length and varies in width from 8–23 km. The highest elevation in the basin is Mt. Fernow at 2,819 m and the lowest is the confluence with the Columbia River at approximately 213 m (USDA 1979). Fish migrating to the Entiat River travel through eight

main-stem Columbia River hydroelectric dams including; Bonneville, Dalles, John Day, McNary, Priest Rapids, Wanapum, Rock Island, and Rocky Reach dams.

Chinook Salmon spawning ground surveys on the Entiat River include most of the known available spawning habitat. The two runs of Chinook Salmon use overlapping habitat in some areas of the river and in other areas their spawning habitat is segregated. In the upper river section, reaches 1 through 5 (rkm 26.1–45.2), both spring and summer Chinook Salmon spawning habitat is available. Only spring Chinook Salmon are known to spawn in the Mad River survey reach (rkm 2.4–5.6). Only summer Chinook Salmon are known to spawn in reaches H and F (rkm 0.5–10.9). Refer to Appendix A for additional reach descriptions.

FIGURE 1.—Map of the Entiat River basin and the spawning ground survey reaches. The beginning and end of all surveyed reaches are marked with black dots. The survey reaches are located between the black dots and labeled 1–5, H, F, and MR. Main-stem Columbia River dams are represented by black squares on the Washington State outline map (WA).

Salmon Populations

The Entiat River has historically supported salmon runs consisting of Chinook Salmon and Coho Salmon (Craig and Suomela 1941). In the late 19th century numerous dams were constructed on the lower 16 river kilometers of the Entiat River for milling, logging and power generation (Long 2001). These dams impeded the migration of salmon to their natal spawning grounds. By 1939 salmon were extirpated from the Entiat River (Craig and Suomela 1941). Some mill dams on the Entiat River had fish ladders, but were ineffective in passing fish (USBF 1934/1935/1936). From 1939 to 1943, as part of the Grand Coulee Fish Maintenance Project, late-returning adult salmon (mainly summer and fall Chinook Salmon) were trapped at Rock Island Dam and relocated to tributaries below Grand Coulee Dam, including the Entiat River, and to hatcheries, including Leavenworth, Entiat, and Winthrop National Fish Hatcheries (Fish and Hanavan 1948). The goal of the relocation effort was to rebuild salmon runs in mid-Columbia tributaries and mitigate for lost production above Grand Coulee Dam. The last mill was closed in 1979 and with it the last channel spanning dam on the Entiat River was removed.

Spring Chinook Salmon

In the initial years after Grand Coulee Dam was built (1939–1941), little effort was made to re-establish natural spring Chinook Salmon runs in the Entiat River. From 1942 to 1944, the Entiat National Fish Hatchery (NFH) used brood stock from upriver stocks collected at Rock Island Dam to rear and release a total of 1.3 million sub-yearlings and ~50,000 yearling spring Chinook Salmon (Mullan 1987). Spring Chinook Salmon production at Entiat NFH was terminated in 1945 and re-activated in 1974. Egg sources included: Cowlitz River (1974), Carson NFH (1975–1982), Little White Salmon NFH (1976, 1978, 1979, 1981), Leavenworth NFH (1979–1981, 1994), and Winthrop NFH (1988). Adults that voluntarily returned to the hatchery were the primary brood stock in 1980 and from 1983 to 2006. The last spring Chinook Salmon juvenile release into the Entiat River was in 2007, after which the program was again terminated. No Entiat NFH spring Chinook Salmon have been observed since 2010 when the oldest age-class returned to the hatchery.

Natural-origin spring Chinook Salmon were observed spawning in the Entiat River above rkm 29.6 as early as 1956 (French and Wahle 1960). From 1962–1993, Washington Department of Fish and Wildlife (WDFW) annually walked the Entiat River after peak spawning between rkm 34.3–45.2 (reaches 1–3, also referred to in past reports as the *index* area), to count spring Chinook Salmon redds (Appendix B). In 1994, MCRFRO assumed responsibility for monitoring spring Chinook Salmon redds in the Enitat River. At that time MCRFRO also expanded the survey area so that additional downstream reaches were included (below the *index* area), from rkm 26.1–34.3 (referred to as the *expanded* section in prior reports) and a section on the Mad River, from rkm 2.4–5.6.

Summer Chinook Salmon

Summer Chinook Salmon are not considered endemic to the Entiat River however several efforts have been made to establish them following completion of Grand Coulee Dam (Craig and Suomela 1941). In 1939 and 1940, a total of 3,015 adult summer Chinook Salmon, collected at Rock Island Dam from mixed upriver stocks, were placed in upper Entiat River spawning areas, only an estimated 1,308 of these survived to spawn (Fish and Hanavan 1948). The Entiat NFH reared and released juvenile summer Chinook Salmon into the Entiat River from 1941–1964, and in 1976 (Mullan 1987). After termination of the spring Chinook Salmon program at Entiat NFH in 2007, the summer Chinook Salmon program was reinitiated in 2009 and the first juvenile release occurred in 2011. The Entiat NFH summer Chinook Salmon egg sources have included mixed upriver stocks intercepted at Rock Island Dam (1939–1943), Methow River (1944), Carson NFH (1944), Entiat River (1946–1964), Spring Creek NFH (1964), and Wells Hatchery (1974, 2009–2013).

From 1957 to 1991, the Chelan County Public Utility District (PUD) conducted aerial surveys to monitor summer Chinook Salmon spawning in the lower 16.3 river kilometers. No summer Chinook Salmon spawning surveys were conducted in the lower section in 1992 and 1993. In 1994, MCRFRO began surveying redds on foot in the upper river (Upper River Section rkm 26.1–45.2) and portions of the lower river, which included spot checks at the confluence of the Mad River (rkm 16.3) and various sections below the hatchery (< rkm 10.9). In 2006, MCRFRO began using rafts for annual surveys for a continuous stretch of the lower river (the Lower River Section), starting at the hatchery and concluding at the influence of the Columbia River (rkm 0.5–10.9).

Natural-origin summer Chinook Salmon can exhibit one of three distinct freshwater life histories; (age-0) ocean-reared juveniles that spend their first year wintering in the ocean, (age-1) stream-reared juveniles that spend their first year wintering in the stream, and (age-1) reservoir-reared juveniles that spend their first year winter in a reservoir (Healy 1991).

Sockeye and Coho Salmon

Sockeye Salmon are not indigenous to the Entiat River, and have only been stocked on two occasions (1943 and 1944) from Lake Quinault and Lake Whatcom stocks (Craig and Suomela 1941; Mullan 1986). A small run of Sockeye Salmon became established in the Entiat River enabling the Entiat NFH to collect Sockeye Salmon from 1944 to 1963, and distribute juveniles outside of the Entiat River watershed (Mullan 1986). Presently, Sockeye Salmon returning to the Entiat River are natural-origin and out-of-basin hatchery strays.

Coho Salmon runs were largely extirpated in the mid-Columbia River basin prior to 1941 (Mullan 1983). Propagation of Coho Salmon at the federal mid-Columbia hatcheries began in the 1940s and extended into the early 1970s. Chelan and Douglas County PUD's, in cooperation with WDFW, started propagation of Coho Salmon in the 1970's and continued until 1994. In 1996, the Yakama Nation initiated the Mid-Columbia Coho Restoration Program, which is

reintroducing the species into the Wenatchee and Methow sub-basins. Although no Coho Salmon have been released in the Entiat River, Coho Salmon have been observed in the Entiat River since 2001 (Appendix C).

Methods

Spring and Summer Chinook Salmon Redd Surveys

Redd surveys consisted of surveying reaches by walking or rafting downstream on a weekly or bi-weekly basis throughout the spawning period. Fewer surveys were conducted in 2014 than in previous years due to staffing shortages during the presumed Chinook Salmon spawning period. Redds were identified as areas of gravel disturbance larger than 1.5m in length x 0.5m with a distinguishable pit and tailspill area. Each redd was marked with colored flagging hung on nearby vegetation and redd descriptions were recorded, including; length, width, presence of fish and GPS coordinates using a Garmin *Rino*™530.

Spawn timing and spatial distribution of redds were examined for both runs. Peak spawning was designated as the week in which the greatest number of new redds were observed. Spatial distribution of redds was examined throughout the surveyed sections. Spawn timing and the spatial distribution of redds was compared to the 2007–2013 averages (7-year average), because this was a period of consistent survey methods.

Superimposition was determined by visual inspection of summer Chinook Salmon redds to evaluate whether the redd was excavated on top of a spring Chinook Salmon redd. When a summer Chinook Salmon redd was observed we used the presence of flagging on the riparian zone, notes from previous surveys, GPS coordinates and professional judgment to determine whether the construction of the summer Chinook Salmon redd superimposed a previous spring Chinook Salmon redd.

Spring and Summer Chinook Salmon Carcass Recoveries

Carcasses recovered during spawning ground surveys were used to describe the characteristics of the spawning population. Carcasses recovered consisted of all mature adults, including age-2 (precocial or mini-jack) fish. While age-2 fish were sampled, their recovery rate was likely very low and their spawning contribution was unknown. For these reasons they were not included in any of the spawning run escapement calculations.

Field protocols for carcasses follow Crawford et.al (2007). Carcass genders were determined by an external examination of morphological characteristics of the carcass followed by an internal examination of the gonads. Other physical attributes recorded for carcasses included: fork length, post-orbital hypural length, and adipose fin condition (absent, intact, or partial). Scales were removed from carcasses to determine age, origin (natural or hatchery) and juvenile life history type (ocean, reservoir or stream early rearing). Some scales from fish with known ages were

read, our reader was 90% accurate. Tissue samples (fin clips) were taken and archived for future DNA analysis. Carcasses were also scanned for Passive Integrated Transponder (PIT) tags and coded-wire tags (CWT) with portable handheld detectors. If a CWT was present, the snout was removed for tag extraction. Detected PIT tags were recorded but not retained. The caudal (tail) fin was removed from each carcass to indicate that it had been sampled and was then placed back in the stream.

Spawning success was categorized only for females by visually estimating the number of eggs retained within the body cavity (completely spent was defined as <1% of eggs retained, partially spent defined as 2–99% eggs retained, and pre-spawn mortality was defined as total egg retention). This report documents pre-spawn mortality but does not include it in the analysis because surveys started after the beginning of spring Chinook Salmon spawning and therefore mortality before spawning was not documented.

After the completion of the surveys, CWT's and scales were read and recorded. Data was entered into an archived database housed at the MCRFRO, and uploaded to regional databases including the Regional Mark Processing Center (www.rmpc.org), the PIT Tag Information System (www.ptagis.org), and StreamNet (www.streamnet.org).

Sockeye and Coho Salmon Redd Surveys

During Chinook Salmon spawning ground surveys, Sockeye Salmon and Coho Salmon spawning activities were documented, and carcasses sampled. Coho Salmon and Sockeye Salmon redds were determined by the presence of live adults and/or redds of less than 1.5 m x 0.5m wide in substrate < 5 cm diameter. All recovered Sockeye Salmon and Coho Salmon carcasses were scanned for CWT and PIT tags. No scales, genetics, or spawn success data were collected for these species. In past years the number of Sockeye Salmon and Coho Salmon were counted and included in this report, however due to limited sampling and staffing in 2014 these data were only sporadically recorded.

Estimating Salmon Spawning Escapement using Fish/Redd Ratio

Estimating the spawning run escapement (SRE) for both spring and summer Chinook Salmon returning to the Entiat River was calculated as follows:

$$\text{SRE} = \#\ \text{redds} * 2.4\ \text{fish/redd} \quad \text{(Mullan 1990)}$$

For further calculations used in this report refer to Appendix D.

Scale Analysis and Age Determination

Scales were used to identify growth periods (freshwater age and saltwater age) and origin (hatchery or natural) using Gilbert (1912). Age descriptions are presented with the first numeral as the number of winters spent in freshwater (not including the winter of egg incubation), followed by a period, and then the second numeral as the number of winters spent in saltwater

(Koo 1962). Total age, therefore, is equal to one plus the sum of the two numerals. For example, a five year old fish that emigrated to the marine environment as a sub-yearling and returned to the Entiat River would be classified as age 0.4.

Summer Chinook Salmon scales were further examined to determine juvenile life history strategy and primary rearing location. These strategies include ocean type which enter the marine environment as a sub-yearling, reservoir type which spend their first winter in the Columbia River, and stream type which spend their first winter in their natal tributary. To document these rearing strategies we followed Gilbert (1912) classification of ocean and stream types and Connor et. al (2005) classification of reservoir type.

Results

Environmental Conditions

In 2014, the flow regime during Chinook Salmon spawning ground surveys on the Entiat River was slightly below the long-term average (1956–2013; Figure 2). Spawning ground surveys began on September 9 and concluded on October 21. Temporary peaks in flow from rain events can increase turbidity which hinders visibility and can move carcasses from upstream to downstream survey reaches. No such events occurred during surveys in 2014.

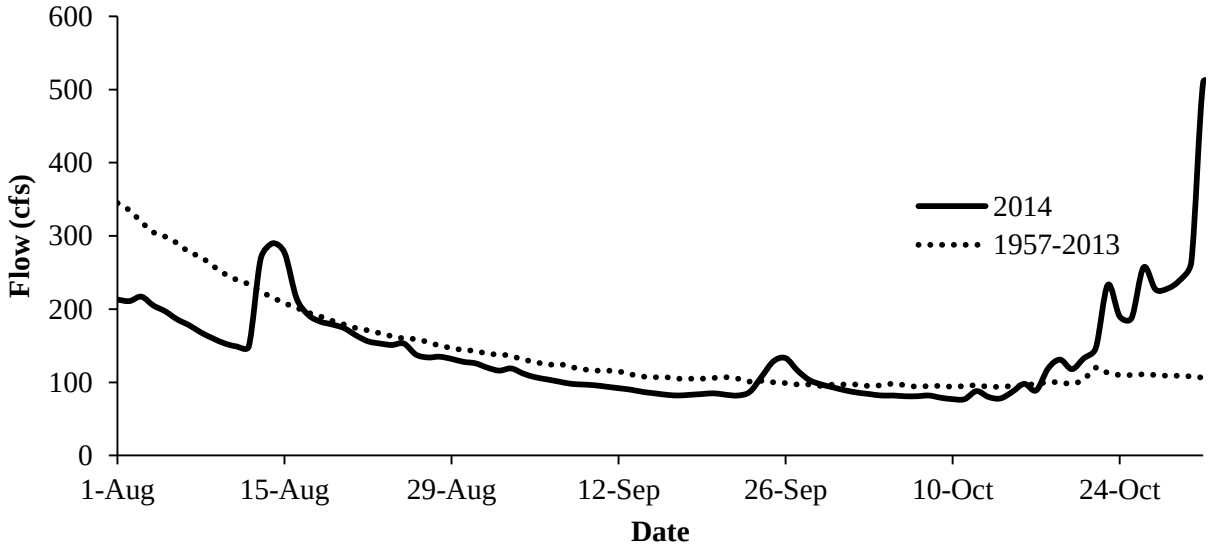


FIGURE 2.—Mean daily flow in the Entiat River for 2014 (solid line) and the long-term mean (1957–2013; dotted line) during the potential Chinook Salmon spawning period from August 1–October 31. Flow data were collected at USGS gauge 12452800, Entiat River near Ardenvoir, WA.

Spring Chinook Salmon

Spring Chinook Salmon spawning ground surveys began on September 9 and concluded on September 26 (Appendix E). Inadequate staffing in 2014 resulted in fewer surveys compared to prior years. Peak spawning based on our surveys occurred during the second week in September, which was the same as the 7-yr average (Figure 3). However, limited surveys may not have captured the true peak spawn timing.

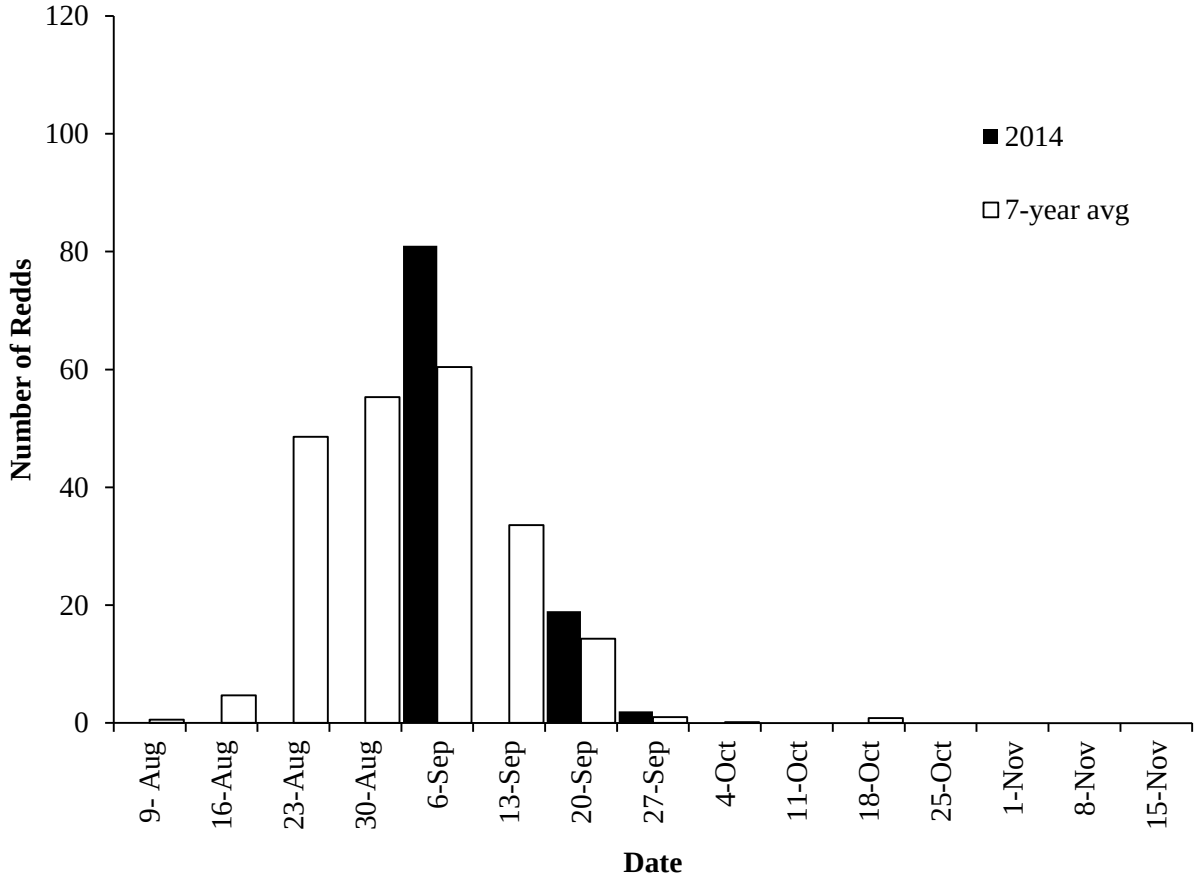


FIGURE 3.—Weekly counts of spring Chinook Salmon redds observed during spawning ground surveys in the Entiat River 2014 (black bars) and the 7-year average (2007–2013; white bars). Surveys were limited in 2014 and may not represent the true peak in spawning. No surveys were conducted from September 10–22.

In 2014, a total of 102 spring Chinook Salmon redds were identified throughout the surveyed portions of the Entiat River. This was 64% of the 7-year average of 160 redds/year. The number of spring Chinook Salmon redds observed in 2014 was among the lowest in the previous ten years (Figure 4). Spatial distributions of redds from reach 1 downstream to reach 5 in 2014 were similar to the 7-year average in which redds were the greatest in reach 2 and decreased upstream and downstream (Figure 5). Unlike previous years the Mad River was not surveyed in 2014.

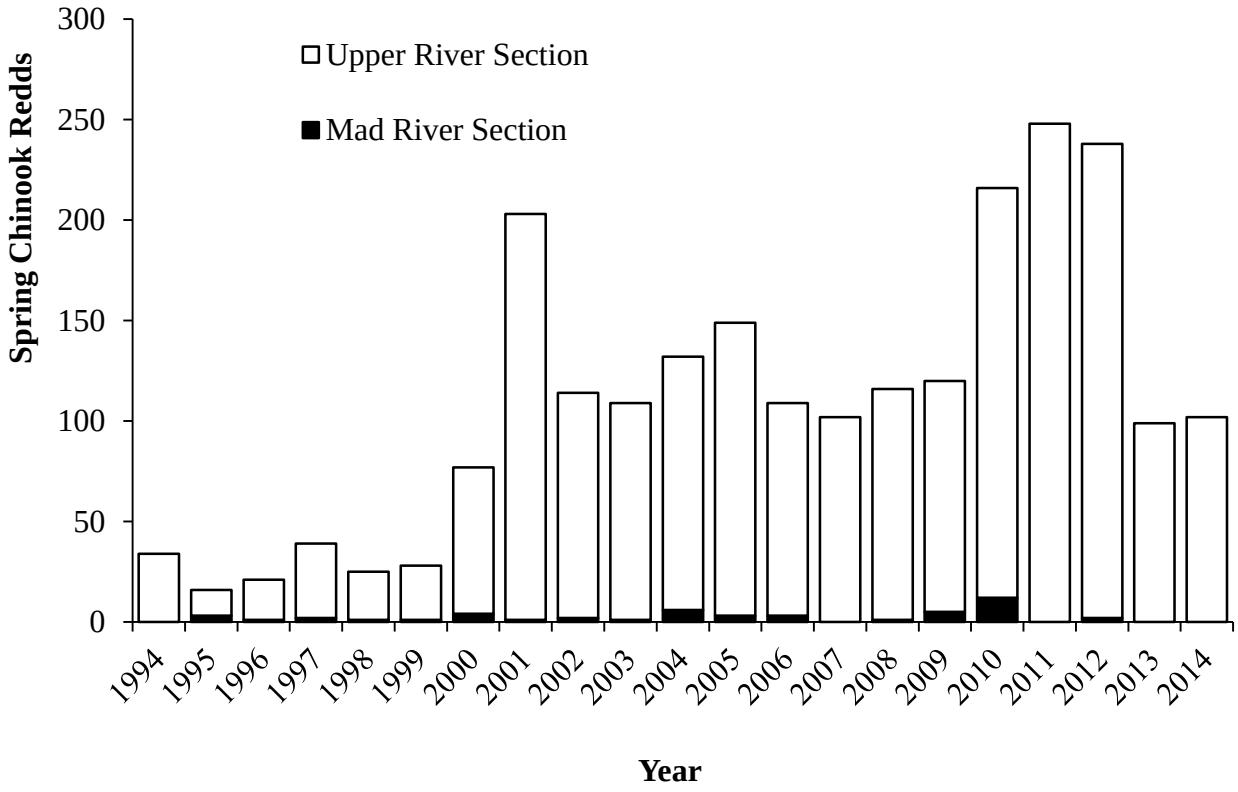


FIGURE 4.—Annual Entiat River spring Chinook Salmon redd counts in the Upper River Section (white bars) and the Mad River Section (black bars). The Mad River was not surveyed in 2014.

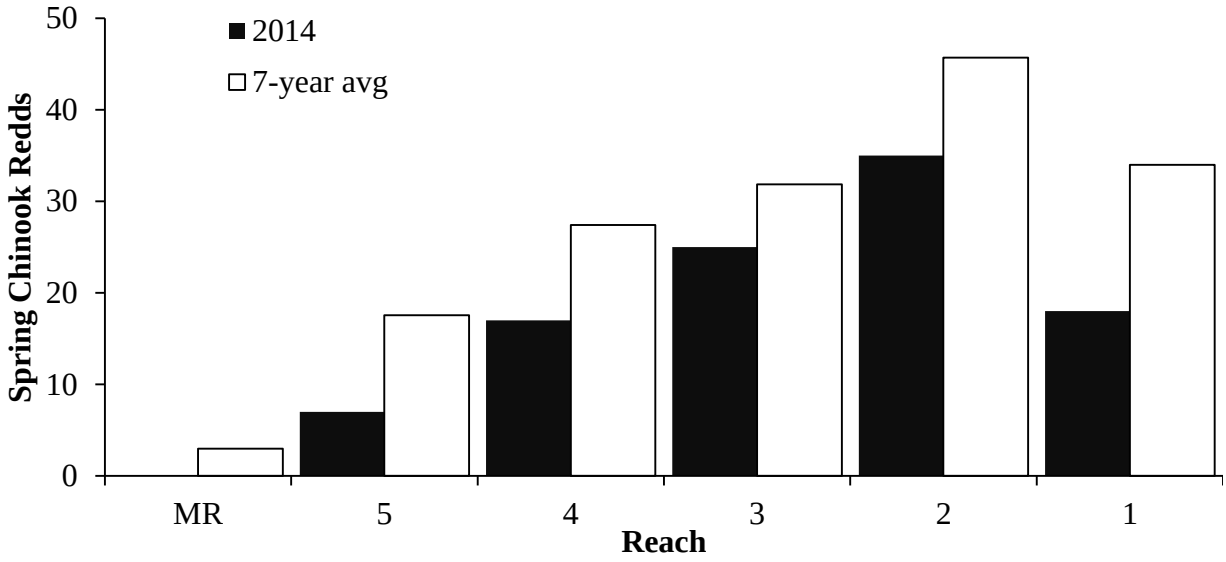


FIGURE 5.—Entiat River spring Chinook Salmon redd counts for reaches 1–5 (rkm 26.1–45.2) in 2014 (black bars) and the 7-year average (2007–2013; white bars). The Mad River was not surveyed in 2014.

Spring Chinook Salmon adult spawning run escapement in 2014 for the Entiat River was estimated to be 245 fish (Table 1). Carcasses of 26 spring Chinook Salmon were recovered, which resulted in a carcass recovery rate of 0.11. Female carcasses outnumbered male carcasses 14 to 9. All 14 female carcasses were examined for spawning success; 9 (64%) were completely spent and 5 (36%) could not be determined because of poor carcass condition.

TABLE 1.—Redd and carcass counts with calculated spawning run escapement (SRE) and carcass recovery rates (CRR) for spring Chinook Salmon in the Entiat River basin from 2006–2014.

Year	Redds	SRE	Carcasses	CRR
2006	106	254	75	0.30
2007	102	245	41	0.17
2008	115	276	80	0.29
2009	115	276	79	0.29
2010	204	490	93	0.19
2011	248	595	173	0.29
2012	236	566	125	0.22
2013	99	238	22	0.09
2014	102	245	26	0.11

Of the 26 spring Chinook Salmon carcasses recovered in 2014, age and origin were determined for 24. The portion of natural origin carcasses was 0.92 (n=22), resulting in an estimated natural origin spawning escapement of 225 fish. The portion of hatchery-origin carcasses was 0.08 (n=2) in 2014, resulting in an estimated hatchery-origin spawning escapement of 20 fish. Hatchery and natural-origin spawning proportions have differed from year to year since 1996 (Figure 6), but since the termination of the Entiat NFH spring Chinook Salmon program in 2007 the portion of natural-origin spawning has increased on the spawning grounds. Hatchery-origin fish were represented by one age-3 male and one age-4 female while the natural-origin fish had various ages and genders (Table 2). The spawning run escapement was represented by 8% age-3, 84% age-4, and 8% age-5 fish.

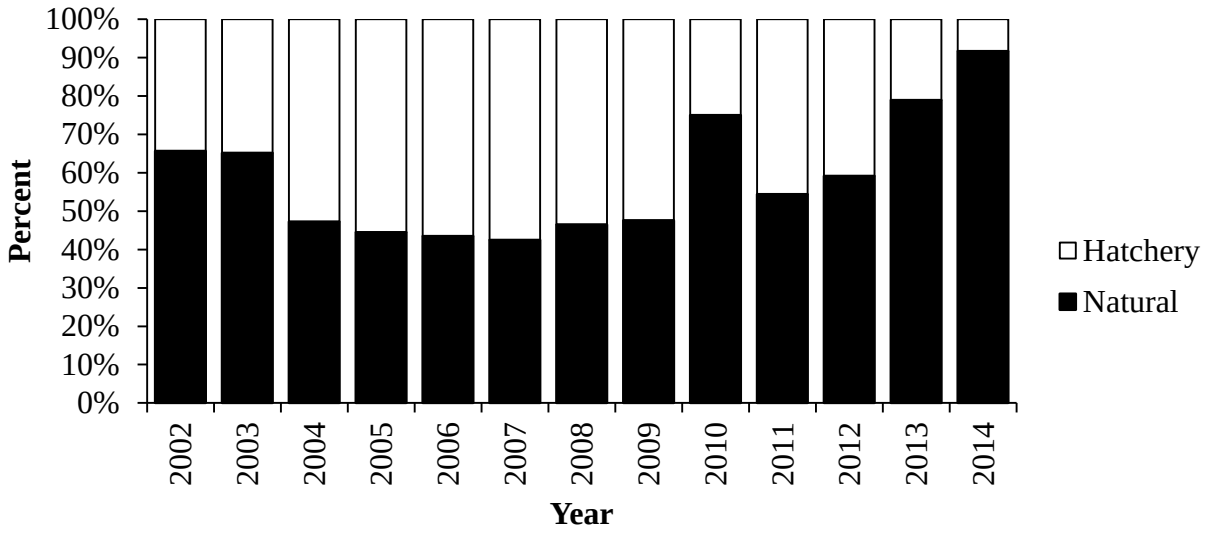


FIGURE 6.—The proportion of hatchery- and natural-origin spring Chinook Salmon spawning run escapement into the Entiat River.

TABLE 2.—Age composition for spring Chinook Salmon sampled from the Entiat River in 2014.

Origin	Age description	Total Age	Male (N)	Female (N)	Total (N)	pSRE	SRE
Natural	0.2	3	0	0	0	0	0
	1.1	3	1	0	1	0.04	10
	1.2	4	8	11	19	0.80	195
	1.3	5	0	2	2	0.08	20
Natural Total			9	13	22	0.92	225
Hatchery	1.0*	2	0	0	0	0	0
	1.1	3	1	0	1	0.04	10
	1.2	4	0	1	1	0.04	10
Hatchery Total			1	1	2	0.08	20
Total*			10	14	24	1.00	245

*Age-2 recoveries that did not spend at least one year in salt water were not included in spawning run escapement (SRE) estimates.

All 26 recovered carcasses were checked for adipose fin, condition and scanned for CWT's and PIT tags. No CWT's were recovered from any of the carcasses and no PIT tags were identified. Refer to Appendix F for data on hatchery-origin spring Chinook Salmon from previous years.

Summer Chinook Salmon

Summer Chinook Salmon spawning ground surveys in 2014 began September 26 and concluded on October 21 (Appendix E). Peak spawning occurred during the last week of September, which was two weeks earlier than the 7-year average (Figure 7).

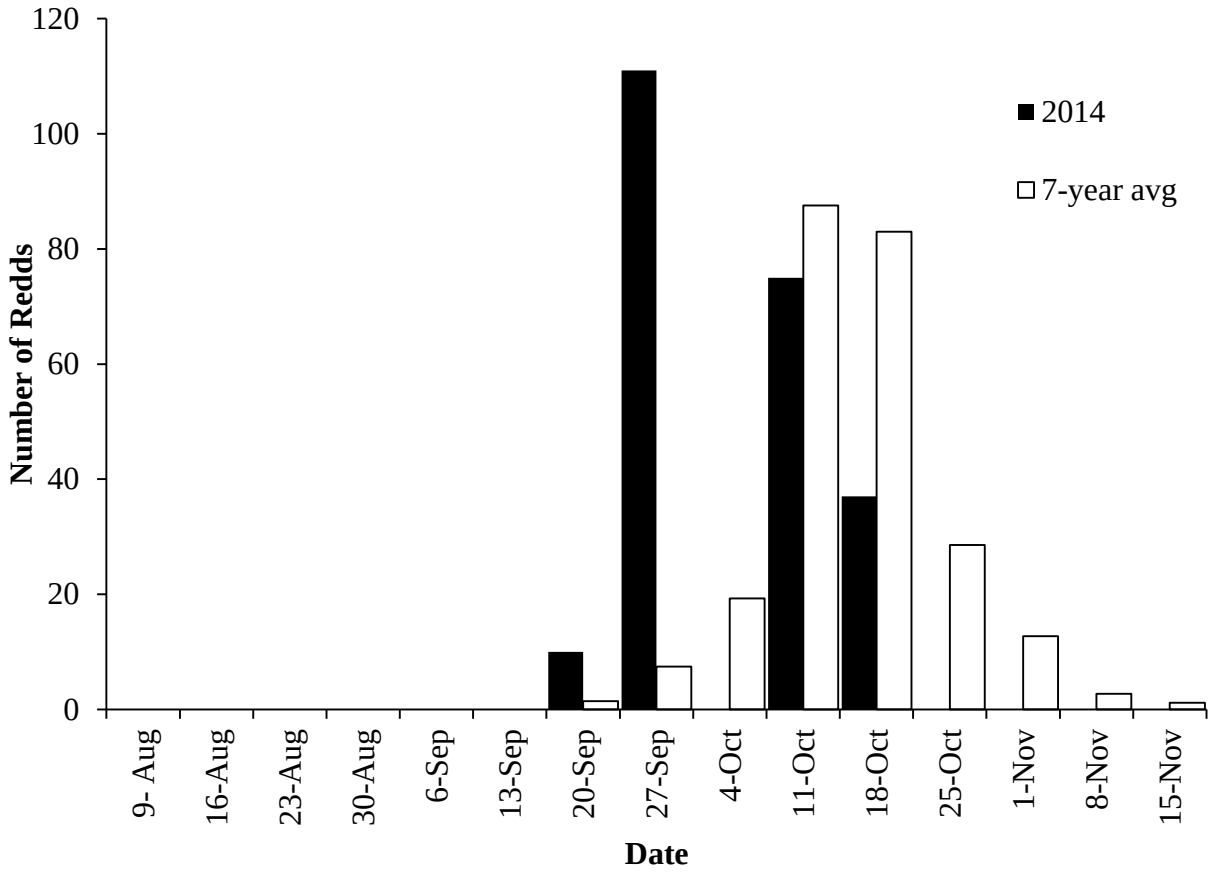


FIGURE 7.—Weekly counts of summer Chinook Salmon redds observed during spawning ground surveys in the Entiat River per week in 2014 compared to the 7-year average (2007–2013). Surveys were limited in 2014 and may not represent the true peak in spawning. No surveys were conducted the week of October 4 or after the week of October 18.

In 2014, a total of 232 summer Chinook Salmon redds were identified during spawning ground surveys. This was 115% of the 7-year average of 201 redds. Most spawning occurred in the Upper River Section (84%), which is consistent with prior years (Figure 8). Spawning distribution in the Upper and Lower River Sections increased in a downstream direction, with more redds in the bottom reaches than in the top reaches (Figure 9) which is very similar to the 7-year average.

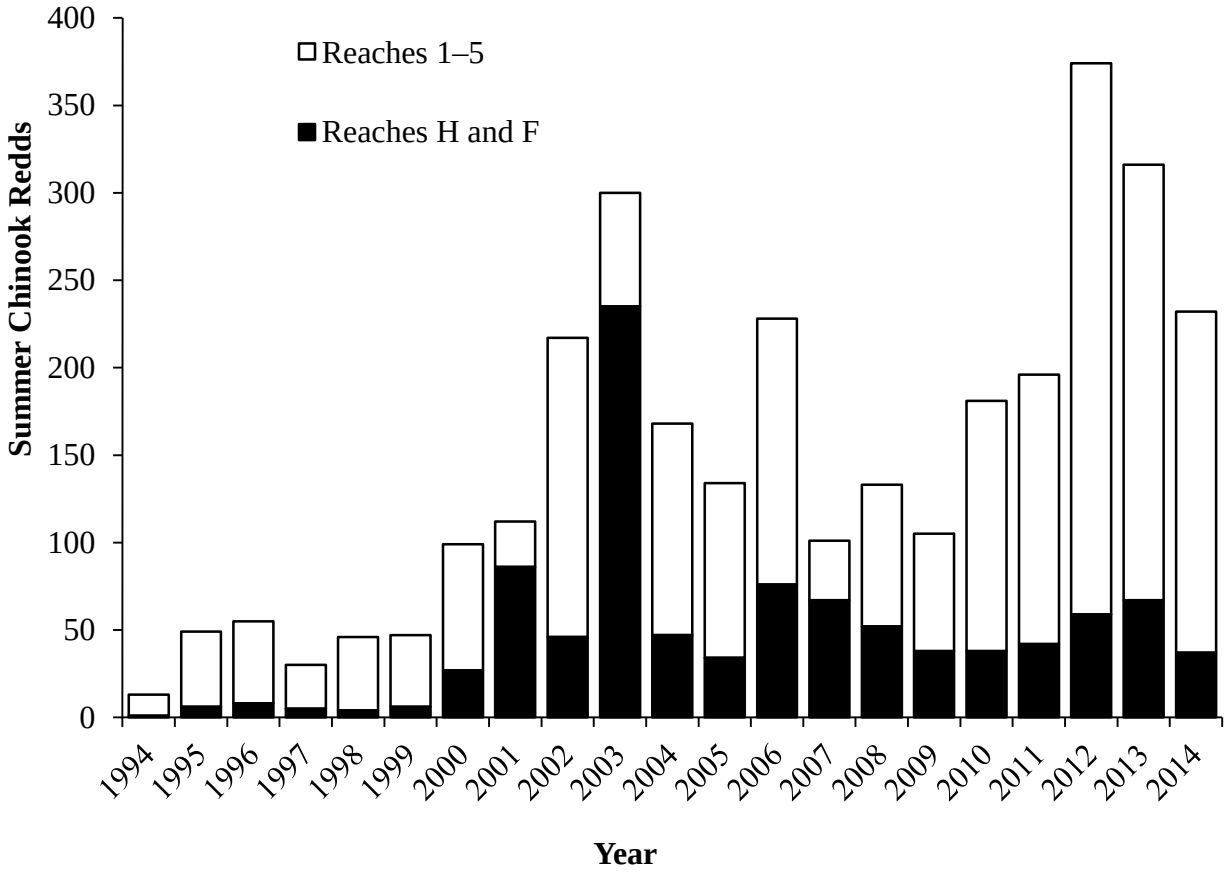


FIGURE 8.—Annual Entiat River summer Chinook Salmon redd counts differentiated by upstream reaches 1–5 (rkm 26.1–45.2) and downstream reaches F and H (rkm 0.5–10.9).

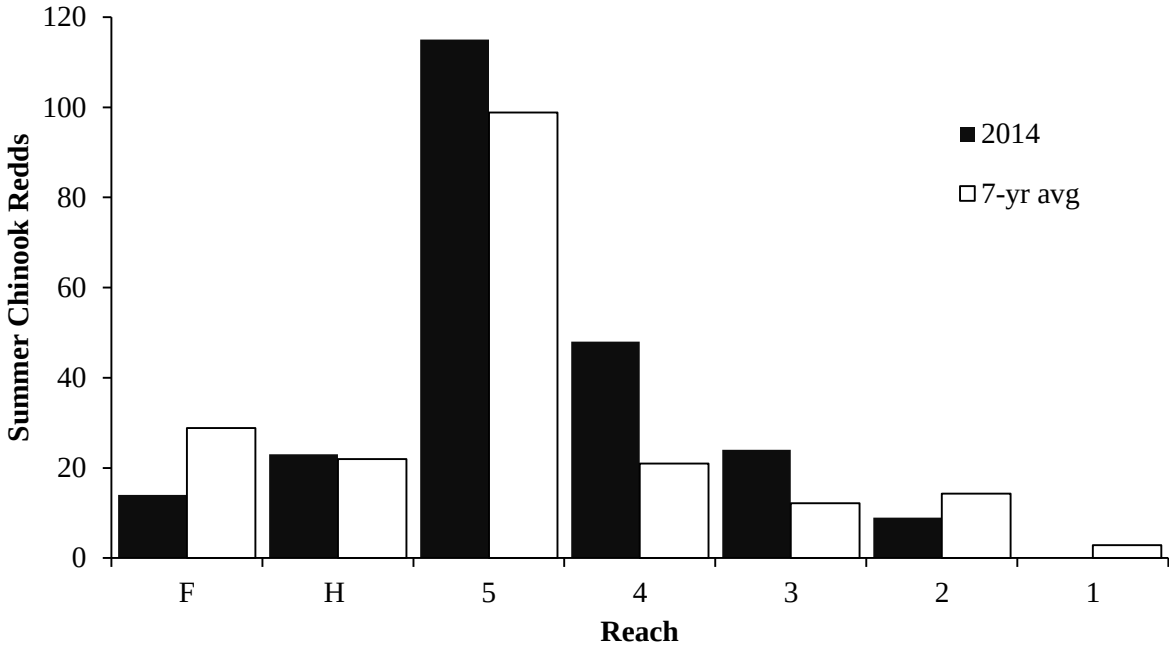


FIGURE 9.—Entiat River summer Chinook Salmon redd counts for reaches F and H (rkm 0.5–10.9) and reaches 1–5 (rkm 26.1–45.2) in 2014 compared to the 7-year average (2007–2013).

The 2014 spawning run escapement for Entiat River summer Chinook Salmon was estimated to be 559 fish (Table 3). Carcasses of 89 summer Chinook Salmon were recovered, which resulted in a carcass recovery rate of 0.16. Unlike spring Chinook Salmon, the summer Chinook Salmon males outnumbered the females 52 to 32. Of the 32 female carcasses examined for spawning success; 8 (25%) were unknown due to decomposition. Of the 24 carcasses that spawning success could be determined 23 (96%) were completely spent, 0 (0%) were partially spent, 1 (4%) were not void of any eggs indicative of pre-spawn mortality.

TABLE 3.—Surveyed number of redds and carcasses with calculated spawning run escapement (SRE) and carcass recovery rates (CRR) for summer Chinook Salmon in the Entiat River basin from 2006–2014.

Year	Redds	SRE	Carcasses	CRR
2006	228	547	180	0.33
2007	101	242	88	0.36
2008	133	319	82	0.26
2009	105	252	83	0.33
2010	181	434	96	0.22
2011	196	470	137	0.29
2012	374	898	207	0.23
2013	316	758	154	0.20
2014	232	559	89	0.16

Of the 89 summer Chinook Salmon carcasses recovered in 2014, age and origin were determined for 84. The portion of natural-origin spawners was 0.75 (n=63), which resulted in an estimated natural-origin spawning escapement of 419 fish. The proportion of hatchery-origin spawners was 0.25 (n=21), resulting in an estimated hatchery-origin escapement of 140 fish. Coded-wire tag and scale analysis indicated various hatchery and natural-origin summer Chinook Salmon age-classes returned to the Entiat River (Table 4). The spawning run escapement was represented by 6% age-2, 19% age-3, 55% age-4, 19% age-5 fish, and 1% age-6 fish. Hatchery- and natural-origin spawning proportions have differed from year to year since 1996 (Figure 10). Based on recovered summer Chinook Salmon carcasses in 2014, hatchery-origin fish have a greater presence in the survey reaches downstream of the Entiat NFH (reaches F and H) compared to reaches 1–5 that are upstream of the hatchery (Figure 11).

TABLE 4.—Entiat River summer Chinook Salmon gender and age composition as the proportion (pSRE) and quantity (SRE) of the spawning run escapement in 2014.

Origin	Age description	Total Age	Male (N)	Female (N)	Total (N)	pSRE	SRE
Natural	0.1	2	5	0	5	0.06	33
	0.2	3	3	12	15	0.18	100
	0.3	4	16	7	23	0.27	153
	0.4	5	7	0	7	0.08	47
	1.1	3	0	0	0	0.00	0
	1.2	4	5	4	9	0.11	60
	1.3	5	1	3	4	0.05	27
	1.4	6	0	0	0	0.00	0
			37	26	63	0.75	419
Hatchery	0.2	3	1	0	1	0.01	7
	0.3	4	1	0	1	0.01	7
	1.0*	2	0	0	0	0.00	0
	1.1	3	0	0	0	0.00	0
	1.2	4	11	2	13	0.15	87
	1.3	5	2	3	5	0.07	33
	1.4	6	0	1	1	0.01	7
			15	6	21	0.25	140
Total*			52	32	84	1.00	559

*Age-2 recoveries that did not spend at least one year in salt water were not included in spawning escapement estimates.

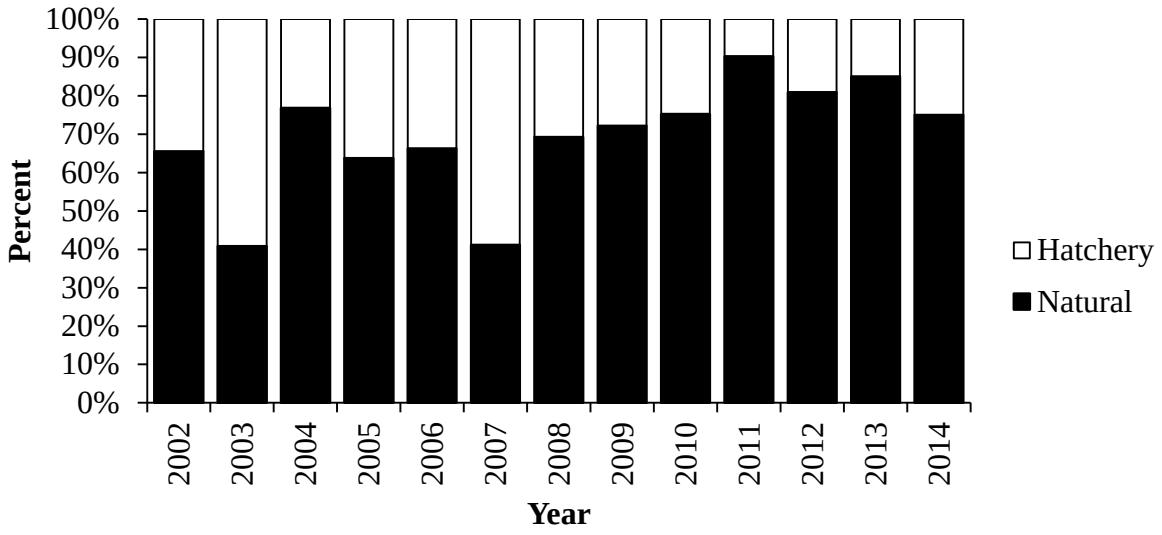


FIGURE 10.—The proportion of hatchery- and natural-origin summer Chinook Salmon spawning run escapement into the Entiat River.

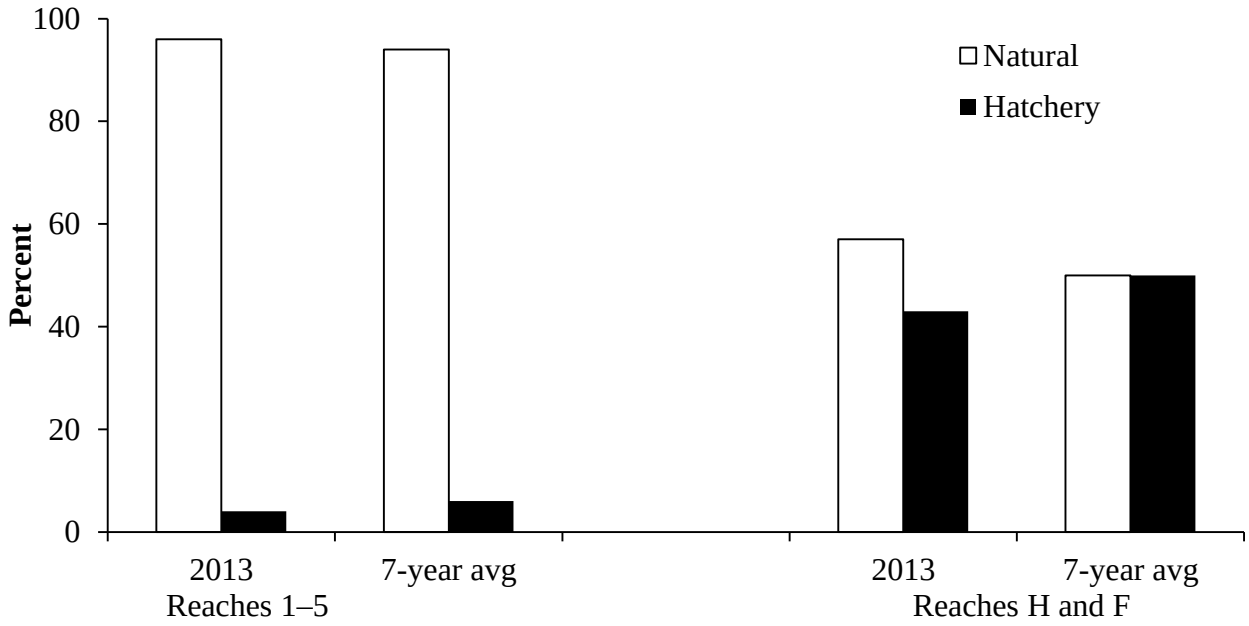


FIGURE 11.—Estimated percent composition of hatchery and natural summer Chinook Salmon spawning in downstream reaches F and H (rkm 0.5–10.9) and upstream reaches 1–5 (rkm 26.1–45.2) of the Entiat River in 2013 and 2014.

Two juvenile life history types were identified for returning natural-origin summer Chinook Salmon in 2014; 79% migrated to saltwater at age-0 and 21% over wintered (age-1) in a reservoir. None were identified as over wintering in their natal stream. Juvenile life history numbers and percentages for years 2006–2014 are found in Table 5.

TABLE 5.—Juvenile life history types and percentages for summer Chinook Salmon sampled from the Entiat River in years 2006–2014.

Year	Ocean (N)	%	Reservoir (N)	%	Stream (N)	%	Total (N)
2006	84	73%	27	23%	4	4%	115
2007	25	74%	9	26%	0	0%	34
2008	42	84%	8	16%	0	0%	50
2009	51	89%	6	11%	0	0%	57
2010	49	72%	19	28%	0	0%	68
2011	88	76%	27	23%	1	1%	116
2012	124	74%	44	26%	0	0%	168
2013	89	71%	36	29%	0	0%	125
2014	50	79%	13	21%	0	0%	63
Avg		76%		23%		1%	

Of the 84 recovered summer Chinook Salmon carcasses from the Entiat River 20 contained a coded-wire tag (CWT). Recovered CWT's revealed that 75% of the hatchery-origin fish that returned to spawn in the Enitat River originated at the Enitat NFH, this was extrapolated to an Entiat NFH spawning run escapement rate based on coded-wire tags (SRECWT) of 99 fish (portion coded-wire tag [pCWT]=0.75, SRECWT=99). Out-of basin strays accounted for 25% of the hatchery influence on the spawning grounds including: 10% Turtle Rock (pCWT=0.10, SRECWT=14), 10% Dryden Acclimation Ponds (pCWT=0.10, SRECWT=14), and 5% Chelan Falls (pCWT=0.05, SRECWT=7; Table 6).

TABLE 6.—Coded-wire tag (CWT) recoveries collected from summer Chinook Salmon carcasses on the Entiat River in 2014**.**

CWT	Brood Year	Release Agency	Hatchery	Carcasses Recovered	Tagging Rate	CWT Expanded	pCWT	SRE CWT
51267	2010	USFWS	Entiat NFH	5	100	31	0.25	33
53568	2009	USFWS	Entiat NFH	1	99	6	0.05	7
53569	2010	USFWS	Entiat NFH	2	100	13	0.10	13
53619	2009	USFWS	Entiat NFH	2	99	13	0.10	13
55364	2010	USFWS	Entiat NFH	5	99	31	0.25	33
635087	2009	WDFW	Turtle Rock	1	97	6	0.05	7
635097	2008	WDFW	Dryden Pond	1	94	7	0.05	7
635577	2009	WDFW	Turtle Rock	1	97	6	0.05	7
635774	2010	WDFW	Chelan Falls	1	95	7	0.05	7
636178	2011	WDFW	Dryden Pond	1	99	6	0.05	7

Data associated with CWT #'s include the hatchery of origin, number of carcasses recovered and the percentage of fish released from the brood year at that hatchery that contained a CWT (tagging rate). CWTExpanded and SRECWT are calculations used to estimate abundance of summer Chinook Salmon in the Entiat River in 2014 based on CWTs. pCWT is the proportion of CWTs that a given CWT represents.

*Age-2 recoveries that did not spend at least one year in salt water were not included in spawning run escapement estimates.

Of the 89 summer Chinook Salmon carcasses recovered from the Entiat River, two were identified as containing a PIT tag (Appendix G). We used PTAGIS to track the outward migration and return migration of these two fish. Both fish were released from the Entiat NFH on April 17, 2012. One recovered PIT tag ID 3D9.1C2D6C50C9 was not detected at any point during its out migration but was detected nine times on its return migration. The first detection was on June 10, 2014 at the Bonneville Fish Ladder and the last was 39 days later in the lower Entiat River on July 19, 2014. The carcass was recovered three months later on October 20, 2014 indicating that the fish was in the Entiat River up to 93 days before spawning. The other PIT tag ID 3D9.1C2D6BE4EA was detected twice during its out migration, once at Rocky Reach Dam Juvenile Fish Bypass on April 22, 2014 and once at McNary Dam Juvenile Fish Bypass on May 17, 2012. On the return migration this PIT tag was detected 11 times, the first detection was on June 9, 2014 at the Bonneville Fish Ladder and the last was in the lower Entiat River on October 14, 2014. This fish was detected four times at the Lower Entiat River Antenna Array between July 7, 20174 and October 14, 2014. The travel time between the first detection at Bonneville

and the first detection at the Lower Entiat River Antenna Array was 28 days. The PIT tag detections on the Lower Entiat River Antenna Array suggest that this fish entered the Entiat River in early July but returned to the Columbia River and resided there until October 3, 2014 when it returned to the Entiat River. This fish likely spawned in the lower Entiat River between October 14 and October 21 of 2014.

Redd Superimposition

Redd superimposition rates by summer Chinook Salmon on spring Chinook Salmon were lowest in upstream reaches and progressively increased downstream. None of the spring Chinook Salmon redds were superimposed on in reach 1(the most upstream reach) and only 11% were superimposed on in reach 2 (Table 7). Further downstream, in reaches 3 and 4, superimposition rates were 36% and 59%, respectively. The highest superimposition rate was 71% in reach 5, the most downstream reach that spring Chinook Salmon surveys were conducted. Superimposition rates increased by 8.3% in 2014 compared to 2013. The percentage of superimposition rates attributed to Entiat NFH-origin summer Chinook Salmon increased from 0.3% to 1.4%.

TABLE 7.—Redd superimposition by summer Chinook Salmon on spring Chinook Salmon redds by reach in the Entiat River in 2014.

Reach	Spring Chinook Salmon redds	Summer Chinook Salmon redds	Spring Chinook Salmon redds superimposed (%)
1	18	0	0 (0)
2	35	12	4 (11)
3	25	23	9 (36)
4	17	56	10 (59)
5	7	158	5 (71)

TABLE 8.—Entiat River natural-origin (NO), hatchery-origin (HO), and Entiat National Fish Hatchery-origin (ENFH) summer Chinook Salmon redd counts, superimposition rates (SI) and superimposition rates by origin in the natural spawning area, 2013–2014.

	Redds				SUS					
Year	SCS	SUS	SCS SI by SUS	SCS SI	NOR	HOR	NOR SI	HOR SI	ENFH pHOS	ENFH SI
2013	99	249	19	19.2%	97%	3%	18.6%	0.6%	1.5%	0.3%
2014	102	196	28	27.5%	95%	5%	26.1%	1.4%	5%	1.4%

Sockeye Salmon

In 2014, 52 Sockeye Salmon redds were detected during Chinook Salmon surveys on the Entiat River. A total of five Sockeye Salmon carcasses were recovered of which two contained a coded-wire tag (Table 9) and none contained a PIT tag.

TABLE 9.—Coded-wire tag (CWT) data recovered from Sockeye Salmon carcasses in the Entiat River in 2014.

Species	CWT	Brood Year	Release Agency	Hatchery	Recovered
Sockeye	635771	2010	WDFW	Lake Wenatchee	2

Coho Salmon

In 2014, 12 Coho Salmon redds were detected during Chinook Salmon surveys on the Entiat River. A total of seven Coho Salmon carcasses were recovered, each carcass had a CWT and none of the carcasses had PIT tags (Table 10).

TABLE 10.—Coded-wire tag (CWT) data recovered from Coho Salmon carcasses in the Entiat River in 2014.

CWT	Brood Year	Release Agency	Hatchery	Carcasses Recovered
190319	2011	Yakama Nation	Winthrop NFH	2
190306	2011	Yakama Nation	Willard NFH	1
190307	2011	Yakama Nation	Wells Hatchery	2
190315	2011	Yakama Nation	Willard NFH	1
190314	2011	Yakama Nation	Wells Hatchery	1

Discussion

Over the last five years the abundance and proportion of hatchery-origin spring Chinook Salmon has declined substantially. The decline is primarily a result of a shift in hatchery production at the Entiat NFH from spring to summer Chinook Salmon. In 2007, the Entiat NFH released its final stock of spring Chinook Salmon. In 2010, the last few spring Chinook Salmon of the 2007 cohort returned to the Entiat River and the total percentage of hatchery-origin spring Chinook Salmon in the Entiat River began to decline. However, carcass data from 2011–2013 showed a higher than expected hatchery-origin composition. The high numbers of hatchery-origin spring Chinook Salmon during these years were possibly the result of increased production and subsequent straying of spring Chinook Salmon released from the Chiwawa Rearing Ponds (RP). Chiwawa RP fish comprised 72–81% of the hatchery-origin spring Chinook Salmon during 2011–2013 (Appendix F). Chiwawa RP release numbers peaked in 2010 when it released 609,789 spring Chinook Salmon into the Columbia River basin. The majority of those fish returned in 2012 and accounted for 81% of the hatchery-origin spring Chinook Salmon found in the Entiat River. Since 2012, the Chiwawa RP has released fewer fish each year and in 2014 only released 222,505 spring Chinook Salmon. The percentage of hatchery-origin spring Chinook Salmon recorded in 2014 was the lowest since the MCRFRO began surveying the Entiat River in 1994. The origin of the two hatchery-origin spring Chinook Salmon found in the Entiat River could not be determined. We expect the trend of low numbers of hatchery-origin spring Chinook Salmon to continue under current hatchery operations at the Entiat NFH and Chiwawa RP. The abundance of redds and subsequently the abundance estimates of spring Chinook Salmon in 2014 were among the lowest in the last decade. Low redd counts in 2014 may be partially due to limited surveys but the low percentage of hatchery-origin fish suggests that the reduction of spring Chinook Salmon production at the Chiwawa RP may have also contributed to the reduction in abundance. This is encouraging as hatchery spring Chinook Salmon straying into the Entiat River is a concern for the long-term genetic integrity of the natural-origin population.

In contrast, the abundance and proportion of hatchery-origin summer Chinook Salmon in the Entiat River have increased over the last five years. The increase was most likely attributed to the switch from spring to summer Chinook Salmon production at the Entiat NFH. The total redd count in 2014 was less than the previous two years but was still among the highest since 2006. The total redd count was likely not a good representation of the amount of redds produced in 2014 due to lack of sampling effort. This assumption is supported by the presence of a bi-modal distribution pattern in 2014 compared to the unimodal pattern observed in prior years. The change in the distribution pattern suggests that a large amount of redds were not counted the week of October 4 which may have included the peak spawning period. Additionally, unlike previous years no surveys were done after the week of October 18. The high number of redds counted with limited sampling effort in 2014 suggests that the spawning run escapement (SRE) may have been much larger than we estimated because the SRE is calculated as a function of the total redd count. The proportion of hatchery-origin summer Chinook Salmon (pHOS) was 25% but 75% (~19% of pHOS) of these hatchery-origin fish originated from Entiat NFH. The high percentage of Entiat NFH origin fish indicates that these fish are beginning to substantially augment the population spawning in the river.

Although redds of both runs overlapped spatially there were substantial differences between the abundance of redds in upstream and downstream sections of the Entiat River. Summer Chinook Salmon redds were primarily found in the downstream sections (reaches 4–5) while the spring

Chinook Salmon redds were primarily found in the upstream sections (reaches 1–3). Spring Chinook Salmon generally spawn earlier in the year which puts their redds at risk of superimposition by summer Chinook Salmon that typically spawn later in the year. Spring Chinook Salmon that spawned in the upper reaches of the Entiat River are at lower risk for superimposition than those that spawned farther downstream. Although superimposition rates from Entiat NFH-origin summer Chinook Salmon on spring Chinook Salmon redds were only 1.4% they increased from 0.3% in 2013. Management goals for the Entiat NFH state the acceptable superimposition rates of Entiat NFH-origin Chinook Salmon on spring Chinook Salmon to be 10% (NFMS 2013). Monitoring superimposition rates will continue to be a priority for the MCFRO because rates will likely continue to increase in the near future as full-production summer Chinook Salmon runs from the Entiat NFH return to the Entiat River.

In conclusion, the change in hatchery operations over the last five years affected both the abundance and the percent of hatchery-origin Chinook Salmon in the Entiat River. Spring Chinook Salmon abundance in the Entiat River has declined since the termination of the Entiat NFH spring Chinook Salmon program and the reduction in the production of spring Chinook Salmon at the Chiwawa RP. However, the high percentage of natural-origin spring Chinook Salmon and their continued presence in the Entiat River without hatchery supplementation is encouraging for the persistence of this ESA-listed population. Conversely, summer Chinook Salmon abundance and the proportion of hatchery-origin fish are increasing due to full production releases from Entiat NFH.

Summary

The total number of spring Chinook Salmon redds counted during the 2014 spawning ground surveys was 102, with an estimated adult spawning run escapement of 245 fish to the Entiat River. A total of 26 carcasses were recovered; females comprised 58% and males comprised 42%. The spawn success rates of females was 100% completely spent and 0% incomplete, however five female carcasses could not be determined because of poor carcass condition. Recovered carcasses indicate that natural-origin fish comprised 92% of the adult return escapement to the Entiat River and the remaining were 8% of hatchery-origin. No coded wire tags were recovered from spring Chinook Salmon in 2014 so the origin of the one hatchery carcass recovered was not determined.

In 2014, 233 summer Chinook Salmon redds were counted during spawning ground surveys, with an estimated adult spawning run escapement of 559 fish to the Entiat River. A total of 89 carcasses were recovered; females comprised 67% and males 33%. Spawning success was determined for 75% of female carcasses (25% too decomposed) and of these 96% were completely voided of eggs and 4% were incomplete/pre-spawn mortalities. Recovered carcasses indicated that natural-origin fish compromised 75% of the adult spawning escapement to the Entiat River and 25% were of hatchery-origin. Scale analysis revealed natural-origin summer Chinook Salmon had two distinctive life histories; 79% were ocean-type juvenile migrants and 21% were reservoir-type juvenile migrants. A total of 20 CWT's were recovered from carcasses. Based on the CWT recoveries hatchery summer Chinook Salmon carcasses were from Entiat NFH (75%), Dryden Acclamation Pond (10%), Turtle Rock Hatchery (10%), and Chelan Falls Hatchery (5%).

Acknowledgements

Thanks to the following individuals for their assistance with the spawning ground surveys, data entry and validation; Matt Cooper, Jeff Muchard, Matt Hall, Robbette Schmit, Ken Poczekaj, John Box and William Gale.

References

Connor, W.P., J.G. Sneva, K.F. Tiffan, R.K. Steinhorst, and D. Ross. 2005. Two alternative juvenile life history types for fall Chinook salmon in the Snake River. Transactions of the American Fisheries Society 134:291–304.

Craig, J.A. and A.J. Suomela. 1941. Time of appearance of the runs of salmon and steelhead trout native to the Wenatchee, Entiat, Methow, and Okanogan rivers. USFWS Unpublished Manuscript

Crawford, B., T.R. Mossey, and D.H. Johnson 2007. Carcass Counts. Pages 59–94 *in* D.H. Johnson, Shrier B.M., J.S. O'Neal, J.A. Knutzen, Augerot X., T.A. O'Neal, and T.N. Pearsons, editors. Salmonid Field Protocols Handbook:Techniques for assessing status and trends in slamon and trout populations. American Fisheries Society, Bethseda, Maryland.

Fish, F.F. and M.G. Hanavan. 1948. A report on the Grand Coulee Fish Management Project 1939–1947. USFWS Special Scientific Report 55

French, R.R. and R.J. Wahle. 1960. Salmon runs- upper Columbia River, 1956–1957. USFWS Special Scientific Report 364

Gilbert, C.H. 1912. Age at maturity of the pacific coast salmon of the the genus Oncorhynchus. Bulletin of the Bureau of Fisheries 32:1–22.

Healy, M.C. 1991. Life history of Chinook salmon (Oncorhyncus tshawytscha). Pages 312–393 *in* C. Groot and L. Margolis, editors. Pacific salmon life histories. UBC Press, Vanouver, Canada.

Koo, T.S.Y. 1962. Age designation in salmon. Pages 37–48 *in* T.S.Y. Koo, editors. Studies of Alaskan red salmon. University of Washington Press, Seattle, Washington.

Long, A. 2001. Under the Guard of the Ole Tyee. Wenatchee, WA.

Mullan, J.W. 1983. Overview of artificial and natural propogation of coho salmon on the mid-Columbia River. USFWS Report No. FRI/FAO-84-4

Mullan, J.W. 1986. Determinants of sockeye salmon abundance in the Columbia River, 1880s–1982: A reiew and synthesis. USFWS USFWS Biological Report 86(12)

Mullan, J.W. 1987. Status and propogation of Chinook salmon in the Mid-Columbia River through 1985. USFWS Biological Report 89(3)

Mullan, J.W. 1990. Status of Chinook salmon stocks in the mid-Columbia. Pages 45–55 *in* D.L. Park, editors. Status and future of spring Chinook salmon in the Columbia River Basin-conservation and enhancement. US Dept. Commerce, NOAA Tech. Memo. NMFS F/NWC-187.

Mullan, J.W., K.R. Williams, G. Rhodus, T.W. Hillman, and J.D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. USFWS Monograph.

NMFS. 2013. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion: Entiat National Fish Hatchery Summer Chinook Hatchery Program. NMFS Consultation Number: NWR-2012-00841

USBF. 1934/1935/1936. Entiat River physical stream survey report. US Bureau of Fisheries

USDA. 1979. Enitat: cooperative river basin study. US Department of Agriculture

APPENDIX A- Entiat River Survey Reach Descriptions

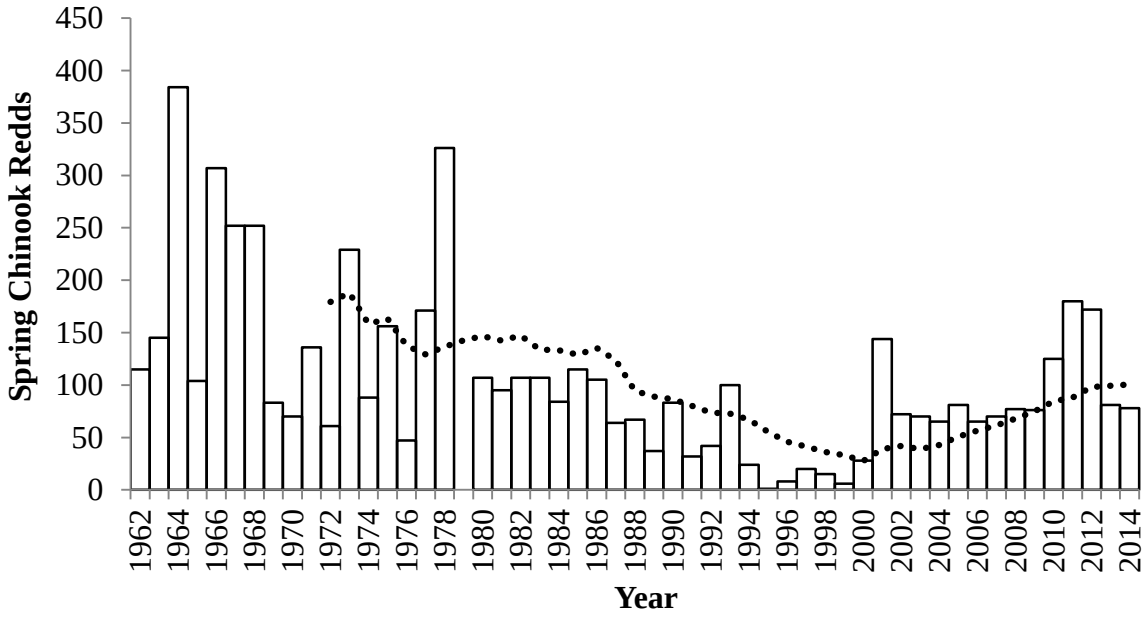
Reach	River Kilometer	Surveyed Kilometers	Description
1	41.5–45.2	3.7	Forest Service boundary to Fox Creek camp ground
2	37.7–41.5	3.8	Fox Creek camp ground to Brief Bridge
3	34.3–37.7	3.4	Brief Bridge to Kelsey Lane Bridge
4	30.1–34.3	4.2	Kelsey Lane Bridge to Stormy Creek preserve
5	26.1–30.1	4.0	Stormy Creek Preserve to McKenzie Diversion
H	5.0–10.9	5.9	Entiat NFH to Fire Station
F	0.5–5.0	4.5	Fire Station to Columbia River influence
MR	2.4–5.6	3.2	Mad River, Pine Flats Campground to road sign

*Kelsey Lane Bridge referred to as Foss Bridge in prior reports.

APPENDIX B- Spring and Summer Chinook Salmon Annual Redd Counts for the Entiat River

Entiat River spring Chinook Salmon redd counts (Redds) from annual surveys in old *index* area, Fox Creek C. G. to Dill Creek (rkm 34.3–45.2, reaches 1–3), 1962–1993 (WDFW) and 1994–2014 (USFWS).

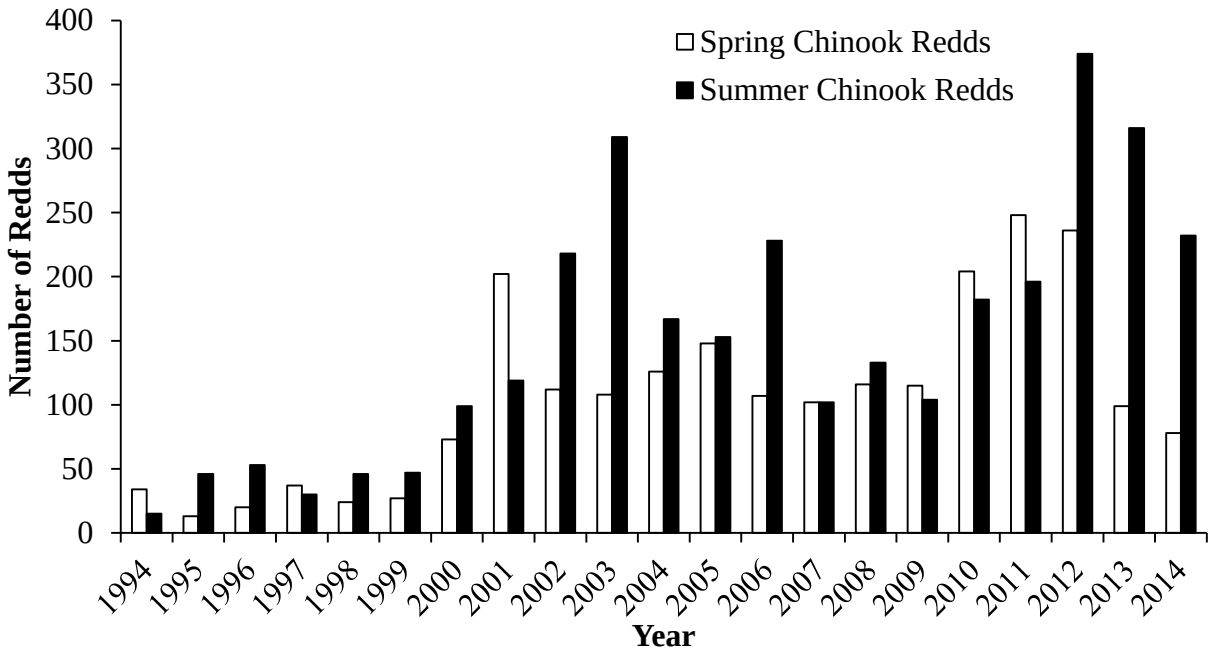
Year	Redds	Year	Redds	Year	Redds	Year	Redds
1962	115	1976	47	1990	83	2004	65
1963	145	1977	171	1991	32	2005	81
1964	384	1978	326	1992	42	2006	65
1965	104	1979	NA	1993	100	2007	70
1966	307	1980	107	1994	24	2008	77
1967	252	1981	95	1995	1	2009	76
1968	252	1982	107	1996	8	2010	125
1969	83	1983	107	1997	20	2011	180
1970	70	1984	84	1998	15	2012	172
1971	136	1985	115	1999	6	2013	81
1972	61	1986	105	2000	28	2014	78
1973	229	1987	64	2001	144		
1974	88	1988	67	2002	72		
1975	156	1989	37	2003	70		



Entiat River spring Chinook Salmon redd counts in the *index* area, rkm 34.3–45.2 (reaches 1–3), and the 10-year moving average (dotted line).

Entiat River spring and summer Chinook Salmon redd counts from the summation of redd surveys observed in reaches 1–5 (rkm 2.4–5.6), reaches H and F (rkm 0.5–10.9) and the Mad River, 1994–2014.

Year	Spring Chinook Salmon	Summer Chinook Salmon
1994	34	15
1995	13	49
1996	20	55
1997	37	30
1998	24	46
1999	27	47
2000	73	99
2001	202	112
2002	112	217
2003	108	300
2004	126	168
2005	146	155
2006	106	228
2007	102	101
2008	115	133
2009	115	105
2010	204	181
2011	248	196
2012	236	374
2013	99	316
2014	78	232



Spring and summer Chinook Salmon redd counts for the Entiat River, 1994–2014.

APPENDIX C- Sockeye Salmon and Coho Salmon Annual Redd Counts for the Entiat River

	Sockeye Salmon	Coho Salmon
1994	0	-
1995	0	-
1996	0	-
1997	0	-
1998	3	-
1999	0	-
2000	2	-
2001	10	12
2002	139	0
2003	15	0
2004	39	5
2005	42	2
2006	9	1
2007	1	6
2008	16	6
2009	23	0
2010	138	0
2011	35	10
2012	52	0
2013	180	10
2014	51	12

APPENDIX D- Calculations

Carcass Recovery Rate

Estimating the carcass recovery rate (CRR) for both spring and summer Chinook Salmon returning to the Entiat River to spawn was calculated as follows:

$$\mathrm{CRR} = \frac{\mathrm{Carcasses}}{\mathrm{SRE}}$$

Where: Carcasses is the number of examined carcasses, and SRE is the estimated total spawning run escapement of adults to the river.

Estimating Natural-origin Spawners

(1) To calculate the proportion of natural-origin spawners (pNOS);

$$\mathrm{pNOS} = \frac{\mathrm{NOC}}{\mathrm{TC}}$$

Where: NOC is the number of natural-origin carcasses recovered, and TC is the total number of known origin carcasses recovered.

(2) To calculate the number of natural-origin spawners (NOS);

$$\mathrm{NOS} = \mathrm{pNOS} * \mathrm{SRE}$$

Estimating Hatchery-origin Spawners

(1) To calculate the proportion of hatchery-origin spawners (pHOS);

$$\mathrm{pHOS} = \frac{\mathrm{HOC}}{\mathrm{TC}}$$

Where: HOC is the number of hatchery-origin carcasses recovered.

(2) To calculate the number of hatchery-origin spawners (HOS);

$$\mathrm{HOS} = \mathrm{pHOS} * \mathrm{SRE}$$

Estimating Hatchery Contribution by Release Facility

To determine the proportion and origin of hatchery fish found on the spawning grounds we used any combination of scale patterns, adipose fin presence/absence, or tags if present. Coded-wire tags were used to estimate the contribution of hatchery-origin spawners by release hatchery or program. Additionally, coded-wire tags were used to account for untagged hatchery-origin fish

because hatcheries applied tags at different rates to their releases. To estimate the potential number of hatchery-origin spawners represented by a coded-wire tag we expanded each unique tag using the following three-step process:

(1) To calculate the expanded CWT (CWTExpanded) recoveries for each tag code (*x*) recovered;

$$\mathrm{CWT_{Expanded}}^{x} = \frac{(\mathrm{CWT_{obs}}^{x}/\mathrm{CWT_{rate}}^{x})}{\mathrm{CRR}}$$

Where: CWTobs is the number of coded-wire tags recovered or observed for each specific CWT code, CWTrate is the tagging rate for each CWT code, and CRR is the calculated carcass recovery rate calculated in step 1.

.

(2) To calculate the proportion of CWT (pCWT) by tag code (*x*);

$$\mathrm{pCWT}_{x} = \frac{\mathrm{CWT_{expanded}}^{x}}{\Sigma\mathrm{CWT_{expanded}}}$$

(3) To calculate the spawning run escapement (SRECWT) by tag code (*x*);

$$\mathrm{SRE}_{CWTx} = \mathrm{pCWT}_{x} * \mathrm{HOS}$$

APPENDIX E- Spring and Summer Chinook Salmon Spawning Ground Data

Spring Chinook Salmon spawning ground survey results on the Entiat and Mad Rivers in 2014.

Reach	River Km	Date	Redds	Live Fish	Carcasses
1	41.5–45.2	9/9/2014	17	2	1
		9/22/2014	1	1	1
		Total	18	3	2
2	37.7–41.5	9/9/2014	30	13	14
		9/22/2014	4	0	3
		10/1/2014	1	0	0
		Total	35	13	17
3	34.3–37.7	9/9/2014	18	25	0
		9/23/2014	7	0	0
		Total	25	25	0
4	30.1–34.3	9/10/2014	16	8	7
		9/23/2014	1	0	0
		Total	17	8	7
5	26.1–30.1	9/10/2014	0	0	0
		9/26/2014	6	0	0
		10/2/2014	1	0	0
		Total	7	0	0
Mad River	2.4–5.6		-	-	-
		Total			
Area Totals					
Index Area (R 1–3)			78	41	19
Expanded Area (R 4–5)			24	8	7
Upper River (R 1–5)			102	49	26
Mad River			-	-	-

Summer Chinook Salmon spawning ground survey results on the Entiat River in 2014.

Reach	River Km	Date	Redds	Live Fish	Carcasses
1	41.5–45.2	10/1/2014	0	0	0
		Total	0	0	0
2	37.7–41.5	10/1/2014	9	11	0
		Total	9	11	0
3	34.3–37.7	9/23/1014	1	1	0
		10/3/2014	23	19	0
		Total	24	20	0
4	30.1–34.3	9/29/2014	22	33	0
		10/15/2014	26	34	11
		Total	48	67	11
5	26.1–30.1	9/26/2014	10	27	0
		10/2/2014	56	89	0
		10/14/2014	49	71	52
		Total	115	187	52
H	5.0–10.9	10/20/2014	23	21	14
		Total	23	21	14
F	0.5–5.0	10/21/2014	14	14	12
		Total	14	14	12
Area Totals					
Upper River (R 1–5)			195	285	63
Lower River (H, F)			37	35	26
Entiat River (R 1–5, H, F)			232	320	89

APPENDIX F- Hatchery- and Natural-origin Spring Chinook Salmon Composition by Year

Entiat River Spring Chinook Salmon spawning escapement composition for return years, 2004–2014.

							Origin of Hatchery Fish			
Year	Redds	SRE	Carcasses	CRR	Natural %	Hatchery %	ENFH %	LNFH %	CRP %	Other[1] %
2004	126	302	43	0.14	47	53	92	0	0	8
2005	146	367	53	0.14	44	56	67	12	21	0
2006	106	254	75	0.30	43	57	12	8	23	56
2007	102	245	41	0.17	43	58	34	0	23	43
2008	115	276	80	0.29	46	54	39	0	61	0
2009	115	276	79	0.29	48	52	75	8	17	0
2010	204	490	93	0.19	75	25	19	0	26	55
2011	248	595	173	0.29	54	46	0	19	72	9
2012	236	566	125	0.22	59	41	0	0	81	19
2013	99	238	22	0.09	79	21	0	0	80	20
2014	102	245	26	0.11	92	8	0	0	0	100[2]

[1]Includes hatchery populations that were not recovered more than 2x from 2004-2014. These include CWT recoveries from Winthrop NFH, Methow FH, Chewuch Acclimation, Twisp Acclimation, Clearwater FH, Kooskia NFH, Dworshak NFH, Willamette SFH and Sawtooth SFH.
[2]All hatchery-origin carcasses recovered in 2014 were of unknown origin.

APPENDIX G- PIT Tag Recoveries

Passive Integrated Transponder (PIT) tag interrogations from spring Chinook Salmon carcasses on the Entiat River in 2014.

PIT Tag Code	Gender	Release Site	Release Date	Last Detection Site	Last Detection Date
No PIT tags were detected in spring Chinook Salmon carcasses for 2014.					

Passive Integrated Transponder tag interrogations from summer Chinook Salmon carcasses on the Entiat River in 2013.

PIT Tag Code	Gender	Release Site	Release Date	Last Detection Site	Last Detection Date
3D9.1C2D6C50C9	M	Entiat NFH	4/17/2012	Entiat R. ENA	7/19/2014
3D9.1C2D6BE4EA	M	Entiat NFH	4/17/2012	Entiat R. ENA	10/14/2014

Passive Integrated Transponder (PIT) tag interrogations from Sockeye Salmon carcasses on the Entiat River in 2014.

PIT Tag Code	Gender	Release Site	Release Date	Last Detection Site	Last Detection Date
No PIT tags were detected in Sockeye Salmon carcasses for 2014.					

Passive Integrated Transponder (PIT) tag interrogations from Coho Salmon carcasses on the Entiat River in 2014.

PIT Tag Code	Gender	Release Site	Release Date	Last Detection Site	Last Detection Date
No PIT tags were detected in Coho Salmon carcasses for 2014.					

U. S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
7501 Icicle Road
Leavenworth, WA

May 2015